Space Weather Technical Forecast

Issued on Friday, 01 April 2022 at 13:08 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

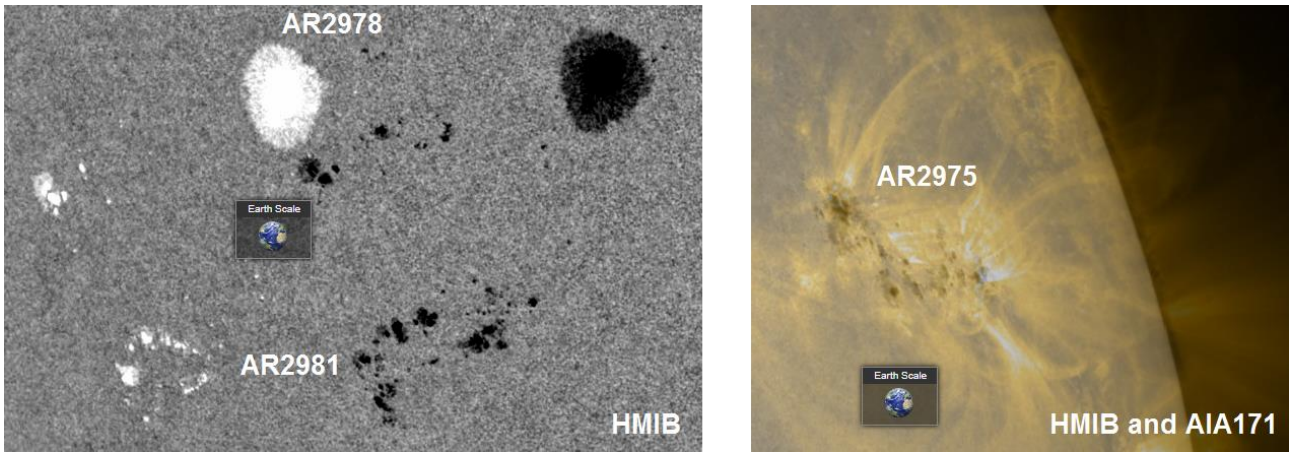
Space Weather Forecast Headline: Risk of Minor/Moderate geomagnetic storms into UTC weekend. M-class flares Likely throughout, with accompanying Slight Chance of solar radiation storms.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been at Moderate levels over the past 24 hours, with GOES 16 recording an M9.6 X-ray flare at 31/1835UTC, which originated from AR2975. This showed concurrent Type II and IV radio bursts, with the speed of ejecta related to the former assessed at 1627km/s. The falling limb of this flare produced another Type II signature, this time with a suggested speed of 856km/s.

X-ray activity was otherwise wholly within C-class, with frequent mid-ranking C-class flares observed from a mixture of sources - including AR2975 in the northwest, but also increasingly AR2981 and AR2978 in the southeastern quadrant. These groups formed three of six total sunspot regions, including two new small unipolar groups that were designated in the period in the eastern hemisphere (AR2982 and 2983).

Figure 0: Left: 24-hour HMIB difference imagery of the southeastern quadrant sunspots – compare white sunspot groups (31/1100UTC) with black (01/1100UTC), with the growth of AR2981 especially evident. Right: Composite image of AR2975 showing Zurich Ekc detail and a proxy for emerging magnetic flux. Imagery processing courtesy of Helioviewer.



Foremost amongst the main sunspot regions was AR2975, which showed an apparent slight decrease in size and fading of its intermediate spots, however this may be in part due to the narrowing viewing angle. There remain candidates for Mt Wilson delta spots in the group, with it ending the period as a Ekc/Beta-Gamma-Delta. In addition to this group, there appears to be a latent 'upwelling' in the southeastern quadrant that is affecting the rapid growth of sunspot region 2981, and also the trailing portion of AR2978 immediately to its north. The former is perhaps the more potent of the two at present, with two minor possible Zurich delta spots now evident, with this

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attaining Dri/Beta-Gamma classification, as 2978 developed into a Eho/Beta. The final group rounding-out the front side population was the relatively large but stable AR2976, which showed Eko/Beta classification over the same interval.

The aforementioned largest flare of the period from AR2975 produced a Coronal Mass Ejection (CME). A cursory CME analysis has been conducted - largely gleaned from available STEREO A COR2 imagery owing to large data gaps in Lasco, and has currently been assessed as a miss ahead of the Earth in the track of its orbit, crossing 1AU around the turn of the UTC day of Monday 04 into Tuesday 05 April. The speed obtained is significantly lower than that suggested by the Type II(s), and further analysis will be conducted should more imagery become available. A second CME was visible heading into the eastward sector on Lasco in the period, however this has been determined to be far-sided, to no Earth effect.

Finally, there are numerous filaments on the disc at present, the largest and most noteworthy of which occupies the south central portion of the sun. Some movement in its trailing portion was observed in the 24 hours, however this is not attributable to anything visible on coronagraphs. Along with other filaments it will be monitored, but particularly in this case given its proximity to any destabilising influence from AR2981.

Solar Wind / Geomagnetic Activity: Earth is currently transiting a sector of space under the influence of a CME magnetic cloud, ongoing since 31/0140UTC. This is thought to be one or both of the 28 March CMEs from AR2975, with the fact that the later emission was travelling faster making it very possible that these features combined into one front. The solar wind is accordingly showing smooth transitions through elevated solar wind measures at present.

The solar wind speed, as measured by DSCOVR at L1, is currently slightly elevated, with an overall decline observed from early highs near 560km/s to reach the high-400s of km/s (having peaked for this event at 629 km/s at 31/1148UTC). The solar wind density peaked near 20ppcc but has since fallen to mid-single figures, with the temperature slightly depressed relative to usual background. The IMF exhibited a smooth rise to peak at 23nT mid-interval, with the north-south component peaking at +17nT, and -9nT. The phi angle was near-neutral at first, but then spent much of the period in a positive sector (away from the sun).

The net result of the above solar wind measures was limited by the co-aligned orientation (with Earth's field) of the magnetic cloud for much of the period. A provisional Minor Storm G1 interval (of Kp 5-) seen in the 12-15UTC interval, with activity otherwise ranging from Quiet to Active.

Energetic Particles / Solar Radiation: The high energy proton flux (10MeV) measured at GOES-16 has shown a gradual relaxation in the period in the wake of the marginal S1 from the 30/1737UTC X1 flare, albeit remaining slightly above Background levels.

The high energy (greater than 2MeV) electron flux as observed by GOES-16 at GEO was at Normal Background levels. The observed fluence at 01/0001 UTC was 1.45e6 integrated pfu, with an initial decline followed by a level trend.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is Likely to be Moderate in the four-day period, mainly the result of recently active AR2975, but perhaps also increasingly AR2981, with a daily Slight Chance of X-class flares. This risk should lessen very slightly into the new working week as AR2975 leaves, although further bright flux regions due over the eastern horizon this UTC weekend may counteract this modest fall.

Solar Wind / Geomagnetic Activity: The 28 March CME(s), arrived in the early hours of 31 March, and the resultant magnetic cloud should continue to affect Earth for the remainder of day

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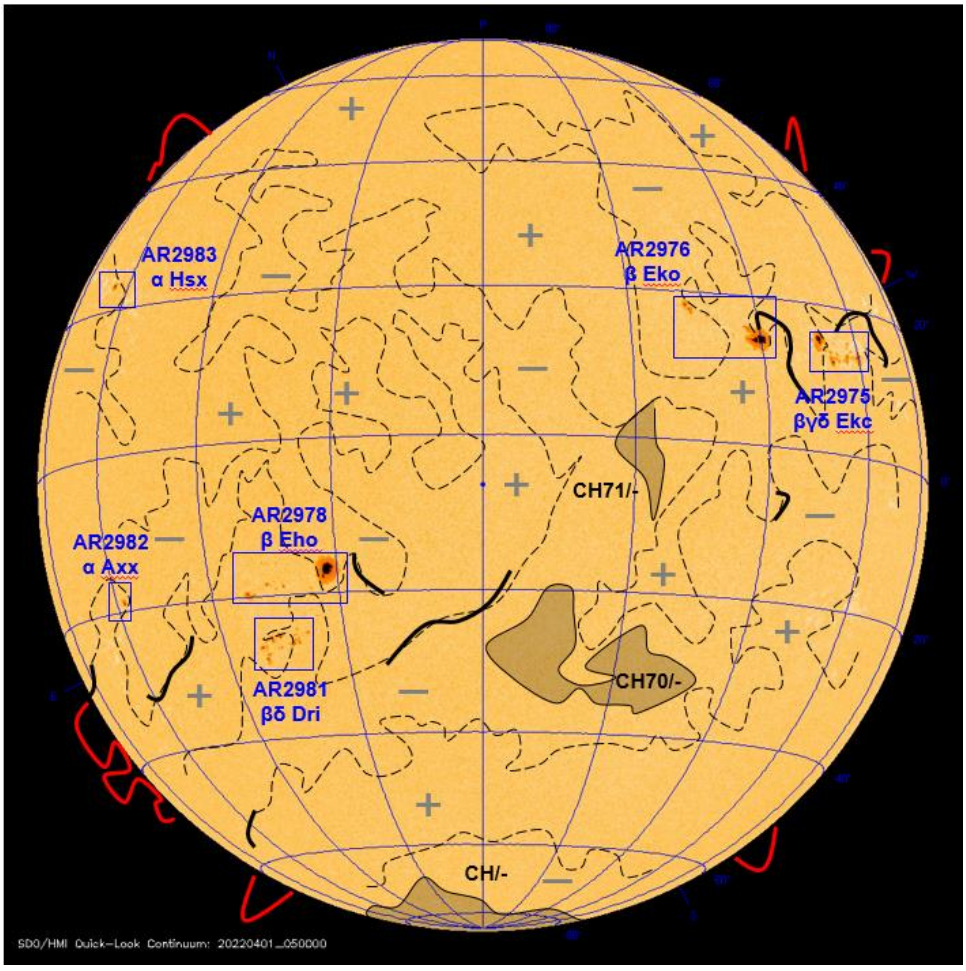
one (01 April), with the chances of G1 resurgent as the magnetic field vector becomes increasingly anti-aligned with Earth's field in the coming hours. On day two, Saturday 02 April, a CME from the 30 March X-class flare may produce a further geomagnetic enhancement around the middle of the UTC day, but confidence is low owing to it being of glancing incidence. Some minor influence is then possible from a pair of coronal holes, 71 and 70 in the second half of the four-day forecast, but perhaps masked by any preceding CME.

G1/G2 Minor to Moderate geomagnetic storms are Likely in the first two days of the period, with the risk peaking on day two, Saturday 02 April, gradually tailing off over the remainder of the UTC weekend and into the new working week.

Energetic Particles / Solar Radiation: The continued activity of AR2975 in particular gives a daily Slight Chance of further potential enhancements above the S1 threshold during the period.
A flat trend is expected at first in the high energy (greater than 2MeV) electron flux. However confidence is low with the CME arrivals likely to at least temporarily attenuate flux levels. Thereafter, some erratic fluctuation is likely, but with a possible eventual rise towards the end of the period. Despite this, the associated 24-hour fluence should most likely remain below the Active (1e8 integrated pfu) threshold throughout.

Figure 1. Solar Analysis Valid 01/0500UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

The 28 March CME(s), arrived in the early hours of 31 March, and the resultant magnetic cloud should continue to affect Earth for the remainder of day one (01 April), with the chances of G1 resurgent as the magnetic field vector becomes increasingly anti-aligned with Earth's field in the coming hours. The absolute peak -Bz reached is likely to be less than the +17nT seen for the positive part of the cloud, with the containing IMF 'envelope' now shrinking. The solar wind should then revert to ambient conditions into day two, Saturday 02 April. Any lull may be short-lived however, with a CME from the 30 March X-class flare possibly producing a further geomagnetic enhancement around the middle of the UTC day. Confidence in this aspect is low, however, owing to it being of glancing incidence. At the time of writing, this concludes the transient-dominated portion of the forecast, although there is the caveat of a pending reanalysis of the expected 'miss' from the M9 flare from the UTC day of 31 March.

Some minor influence is then possible from a pair of coronal holes, 71 and 70. These features have not yet shown conclusively at STEREO A, and confidence in their arrival is therefore limited, also in part because of changes in their geometry since last rotation. Although they are both of negative polarity, they are visually small and tenuous, and definitely form the minor component of the geomagnetic forecast.

G1/G2 Minor to Moderate geomagnetic storms are Likely in the first two days of the period, with the risk peaking on day two, Saturday 02 April, gradually tailing off over the remainder of the UTC weekend and into the new working week.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	60	70	30	5
Strong	G3	No	1	10	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
30/2315	Halo	AR2975	NW quadrant	700	02/1400UTC	Glancing incidence, low confidence.

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Figure 2: Three-day L1 solar wind measures from DSCOVR, showing top to bottom: IMF (blue) and Bz (white); speed and density. The 28 March CME onset can clearly be seen around 31/0140UTC, with the ensuing magnetic cloud sweep also very apparent.

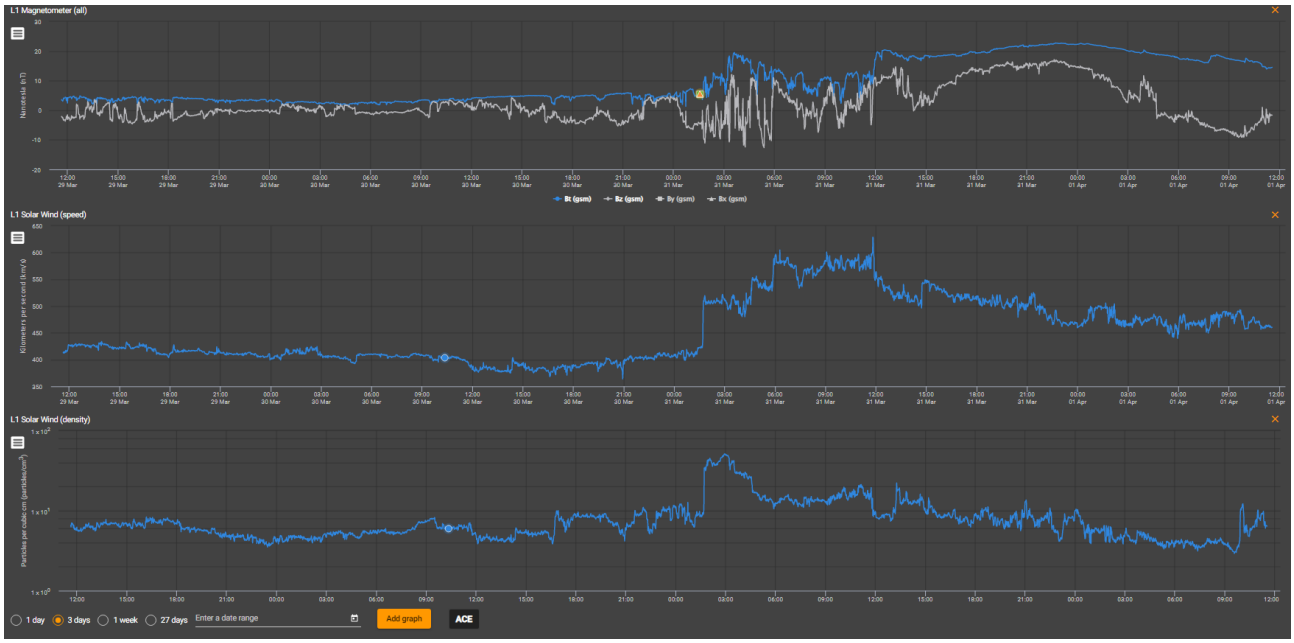
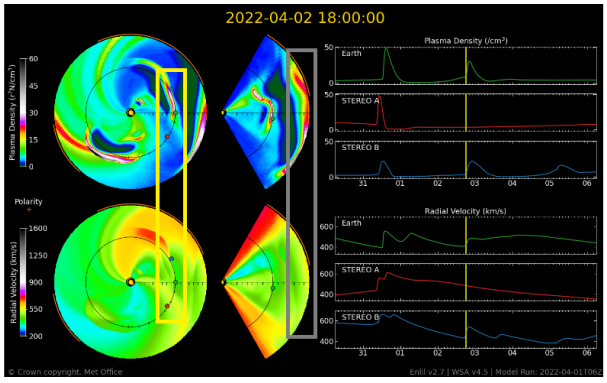
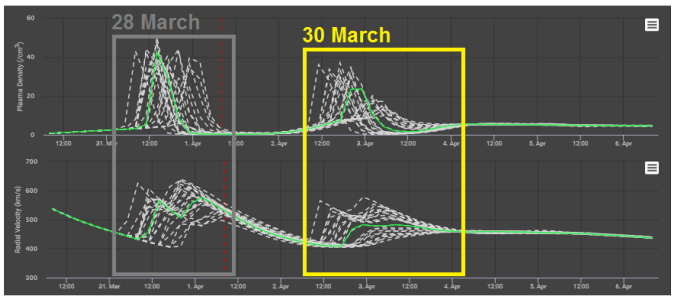


Figure 3: Latest MOSWOC Enlil run and ensemble, showing the current 28 March CME boxed grey, with the forecast glance from the 30 March X-class CME boxed yellow. Also shown is the current forecast miss from the 31 March M9 CME, clearest in the top-down density plot – appearing around 0.25AU and around 30 degrees ahead of Earth in the track of its orbit. This analysis will be confirmed in due course.





Radio Blackouts - X-Ray Flares:

Solar activity has been Moderate in the past 24 hours, with the largest flare an M9.6 at 31/1835UTC, which originated from AR2975. This sunspot group has dominated much of the past week in terms of activity and is likely to continue to do so, with a roughly daily cadence of M/X-class borderline flares and occasional marginal S1-level proton enhancements. Recent HMIIF imagery suggests a possible slight areal decrease in this group, with some fading of intermediate spots, however this may be in part an artefact of the narrowing viewing angle, and it remains large and complex with Ekc/Beta-Gamma-Delta classification.

Another area to watch is the southeastern quadrant and the rapid growth trend in AR2981 over the past 24 hours, with this group showing spreading and significant leading group proliferation, reaching Dri/Beta-Delta by the period's end. All the constituent spots are currently small,

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however there are at least two candidates for delta spots at the time of writing, and this coupled with its growth make it something to monitor.

Added to the above regions of concern are two large but more sedate Zurich E-groups in the form of AR2976 and AR2978, as well as two newly-numbered unipolar regions in the eastern solar hemisphere: AR2982 and 2983.

AR2975 is expected to leave the Earth-facing disc on day four, Monday 04 April, with a consequent drop in the risk of significant flares, although the weight of other regions and presence of AR2981 limits this fall somewhat. Also something to consider is the fact that STEREO A EUVI 195 imagery hints at a bright flux region with a leading edge around 100E, which would put any arrival over the limb over the UTC weekend.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	75	75	75	60
Very Active	R3 to R5 X Class	No	15	15	15	10

Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (10MeV) measured at GOES-16 very briefly reached the S1 level following the 30/1737UTC X1 flare from AR2975, but has since continued its decline.

There remains a daily Slight Chance of further such occurrences, largely as a result of AR2975's continued presence on the disc for most of the period, with this contribution only very slightly lessening as it departs from the front side into the new working week UTC. There is a minor but increasing component to the risk of S1 from AR2981, which is currently in the eastern solar hemisphere but will rotate into an increasingly better-connected location through the four days, with its recent rapid growth something to monitor.

Radiation Storms	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ S1	No	15	15	15	10
Very Active	≥ S3 *	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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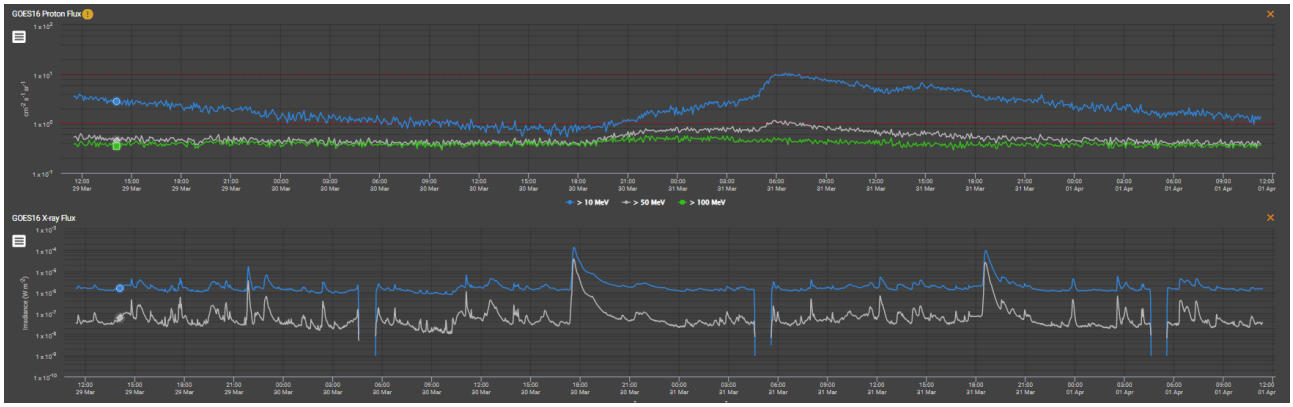
Figure 4: Three-day GOES 16 proton flux (top), showing delayed repsonse to the preceding X-class flare, peaking at S1 and the declining proton spectrum since.



High Energy Electrons Event (≥ 2MeV):

A flat trend is expected at first in the high energy (greater than 2MeV) electron flux. However, from Day 1 (1st April) confidence becomes low with the CME arrivals likely to at least temporarily reduce flux levels. Thereafter, some erratic fluctuation is likely, but with a possible eventual rise towards the end of the period under potential influence of coronal holes 70 and 71. Despite this, the associated 24-hour fluence is more likely than not to remain below the Active (1e8 integrated pfu) threshold.

REFM is considered to be of lower than average utility in the forecast given the impeding transients, however in their possible absence beyond the next 24 hours (for being of glancing incidence) the trend in keeping the fluence below the Active threshold is accepted.

GEO Electron Environment	**Level (cm^{-2} sr^{-1} day^{-1})**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)**	**Day 2 (00-24 UTC)**	**Day 3 (00-24 UTC)**	**Day 4 (00-24 UTC)**
Probability (Exceedance)			**(%)**	**(%)**	**(%)**	**(%)**
Active	**≥ 2 MeV ≥ $1x10^8$**	No	5	10	30	40
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	5	5

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